tions, and the ascension was, therefore, delayed. One balloon started at 10:05 a. m. from Paris, and descended at 4 p. m. in Westphalia, having attained a height of from 14,000 to 16,000 meters, where the temperature was —64° C.

Paris.—The great sounding balloon of 465 cubic meters capacity was sent up from Paris by the French Aerostatic Committee and carried a self-registering actinometer of Violle's construction. This actinometer registered perfectly. It furnishes a continuous clear line upon which we see depicted all the events of the ascension; the departure in cloudy weather, the passage through the clouds, the attainment of the highest point in less than three-quarters of an hour, then a very slow descent during several hours, finally the very rapid descent that brought the balloon to the ground after a sojourn of eight hours in the atmosphere. During the whole of the highest horizontal soaring the black bulb of the actinometer had a constant temperature of —12° C., or about 50° above that of the surrounding air. This actinograph record has apparently given results that are not entirely accordant with current ideas on the subject; it shows that actinometry by means of these atmospheric soundings will give us a better knowledge of solar radiation and atmospheric absorption.

The automatic photographic apparatus of Cailletet, for determining the altitudes, recorded the pressures in an excellent manner, but owing to the cloudiness could not give a direct measurement of altitude.

Trappes near Paris.—Three sounding balloons adjusted to explore different layers in the atmosphere were sent up from the meteorological observatory of M. Teisserenc de Bort. The first started at 3:03 a. m., attained 12,500 meters, with a temperature of —60° C., and was carried by the upper cirrus current toward north 35° east. The second started at 4:55 a. m., attained 9,000 meters, with a temperature of —42°, and traveled northward. The third started at 7:55 a. m., attained 6,800 meters and a temperature of —21°, and traveled toward the north-northwest. The lowest wind blew from the east-southeast, so that the successive upper currents were steadily deflected from this direction toward the right up to the highest, which moved toward the north 35° east.

Strasburg.—A sounding balloon and a manned balloon, as well as a balloon-kite, were used. The latter remained up during twenty-four consecutive hours. The sounding balloon started at 8:30 a. m., moved easterly, attained an elevation of 11,000 meters and a temperature of —50° C.

Brussels.—An ordinary balloon ascended to 1,500 meters.

Berlin.—The balloon manned by Berson started at 2:38 a. m. and descended at 4:15 a. m. During this one hour and thirty-seven minutes, it traveled 160 km. and attained an altitude of 5,500 meters. The balloon manned by Suring attained about 5,300. The balloons manned by Captain Gross and Lieutenant Siegsfeld, respectively, attained about 4,500 meters. Berson found a temperature of —12° C. at 5,500, while Siegsfeld found —8° at 4,500 meters. But, of course, these preliminary results will be changed by subsequent comparison of thermographs. In all manned balloons the temperatures have been observed by means of Assman's ventilated thermometer.

Of the seven sounding balloons, five had been heard from when the report was written. One of the French sounding balloons carried, for the first time, an actinometer, and also Cailletet's photographic altitude apparatus (see the MONTHLY WEATHER REVIEW for October, 1897, p. 443).

Aerophile No. 3, leaving Paris at 2:30 a. m., fell into the hands of some kind-hearted but ignorant persons, who thought that the blackened surface of the cylinder on which the record was registered had been unfortunately blacked by smoke, imagining that the balloon was a *montgolfière* or hot-air balloon, and that the aeronaut had been killed by the combustion of the balloon. They, therefore, thought that they were doing a kindness to clean up the cylinder and polish off the thin layer of lampblack. When Teisserenc de Bort arrived to claim his priceless record, he found the cylinder shining like new, but with no trace of the delicate lines that the stylus had traced when high up in the ethereal blue. However, the kind people gave the aeronaut a charming reception.

Something similar happened to the Parisian balloon that descended in Westphalia. These incidents show that the popular daily journals have not as yet explained the theory of the sounding balloon with sufficient fullness. They show furthermore that Moedebeck, of Vienna, did well to attach to his sounding balloon a strip of cloth a meter broad and six meters long, on which he painted the proper notice in large letters in German, French, Russian, Magyar, and Turkish.

THE SMITHSONIAN WEATHER PREDICTIONS.

An interesting contribution to the history of weather telegraphy in the United States and the development of our knowledge of American meteorology is published on pp. 271–275 of the Proceedings of the American Academy of Arts and Sciences, Vol. IV, for the years 1857–1860. On August 9, 1859, Prof. Joseph Henry, Secretary of the Smithsonian Institution, addressed the Academy on the above subject; probably the published account is generally expressed in his precise words, but there is evidence that it was prepared, at least, in part by the recording secretary of the Academy, Samuel L. Abbot, or by the publication committee whose chairman was Prof. Joseph Lovering, a well-known authority in magnetism and meteorology. The following is a copy of the published record and any additional facts will be gratefully acknowledged by the Editor.

Professor Henry, of the Smithsonian Institution, made a verbal communication relative to the application of the telegraph to the prediction of changes of the weather, particularly in the city of Boston and its vicinity.

It has been fully established by the observations which have been made under the direction of the Smithsonian Institution, and from other sources of information, that the principal disturbances of the atmosphere are not of a local character, but commence in certain regions, and are propagated in definite directions over the whole surface of the United States east of the Rocky Mountains.

From a careful study of all the phenomena of the winds of the temperate zones, it is inferred that over the whole surface of the United States and Canada there are two great currents of air continually flowing eastward. These currents consist of an upper and a lower, the former returning the air to the south which was carried by the latter towards the north. The lower current, which is continually flowing over the surface of the United States, is about 2 miles in depth, and moves from the southwest to northeast. The upper or return current, which is probably of nearly equal magnitude, flows from northwest to southeast, or nearly at right angles to the other, and the resultant of the two is a current almost directly from the west. The reaction of these two currents appears to be the principal cause of the sudden changes of weather in our latitude. They give definite direction to our storms, accordingly as the latter are more influenced by the motion of the one or the other of these great aerial streams. The principal American storms may, from our present knowledge, be divided into two classes; namely, those which have their origin in the Caribbean Sea, and those which enter our territory from the north, at the eastern base of the Rocky Mountains. Those of the first class, which have been studied with much success by the lamented Redfield and others, follow the general direction of the Gulf Stream and, overlapping the eastern portion of the United States, give rise to those violent commotions of the atmosphere which are in many instances so destructive to life and property along our eastern coast. These storms from the south are frequently two or three days in traversing the distance from Key West to Cape Race, and their approach and progress might generally be announced by telegraph in time to guard against their disastrous effects. Though the general direction of these storms appears to be made out with considerable certainty, much remains to be done in settling the theory of their character and formation.

The materials which have been collected at the Smithsonian Institution during the last seven years relative to the other class of storms have enabled us to establish general facts of much value not only in a scientific point of view but also in their application to the prediction of the weather. (This statement was verified by a series of maps ex-

hibited to the Academy by Professor Henry, on which were indicated the beginning and progress of some remarkable changes of weather.) From these maps it appears that the great disturbances of the atmosphere which spread over the surface of the United States enter our territory from the possessions of the Northwest Company, about the sources of the Saskatchewan, at the base of the Rocky Mountains, and are thence propagated south and east until in many instances they spread over the whole of the United States and probably a large portion of the British Possessions.

For example, the great depression of temperature which occurred in January of the present year [1859] and which will be remembered by every one as the most marked cold period of the season entered the territory of the United States at the point before mentioned on the 5th of January, and on the 6th reached Utah, on the 7th Santa Fe, and on the 8th the Gulf of Mexico, and passing onward it was felt at Guatemala on the 10th. While it was advancing southward it was spreading over the continent to the east. On the 7th it reached the Red River settlement, and all places under the same meridian down to the Gulf of Mexico. It reached the meridian of Chicago on the 8th, the western part of the State of New York on the 9th, New England on the 10th, and Cape Race on the 13th. It moved with about equal velocity over the Southern States, and was observed at Bermuda on the 12th.

The remarkable frost of last June, so far as it has been traced, had the same origin, and followed the same eastward course. The fact was also illustrated, by the maps before mentioned, that the warm periods which have occurred in past years have followed the same law of progression, and consequently their approach could have been announced to the inhabitants of the Eastern States several days in advance, had a proper system of telegraphic dispatches been established.

The value of the telegraph in regard to meteorology has been fully proved by the experience of the Smithsonian Institution. The Morse line of telegraph has kindly furnished the Institution during the last twelve months [1858 and 1859], free of cost, with a series of daily records of the weather, from the principal stations over the whole country east of the Mississippi River and south of New York. In order to exhibit at one view the state of the weather over the portion of the United States just mentioned, a large map is pasted on a wooden surface, into which, at each station of observation, a pin is inserted, to which a card can be temporarily attached. The observations are made at about 7 o'clock in the morning, and as soon as the results are received at the Institution, an assistant attaches a card to each place from which intelligence has been obtained, indicating the kind of weather at the time; rain being indicated by a black card, cloudiness by a brown one, snow by a blue one, and clear sky by a white card.

This meteorological map is an object of great interest to the many persons from a distance who visit the Institution daily. All appear to be specially interested in knowing the condition of weather to which their friends at home are subjected at the time. But the value of the map is not confined to the gratification of this desire. It enables us to study the progress of storms, and to predict what changes in the weather may be expected at the east from the indications furnished by places farther west. For example, if a black card is seen in the morning on the station at Cincinnati, indicating rain in that city, a rainstorm may confidently be expected at Washington at about 7 o'clock in the evening. Indeed, so uniformly has this prediction been verified that last winter [1858–59] the advertising in the afternoon papers of the lecture to be delivered at the Institution that evening was governed by condition of the weather in the morning at Cincinnati, a rainy morning at the latter inducing a postponement of the lecture.

It must be evident from the facts given that if a system of telegraphing over the whole country east of the Rocky Mountains were established, information could be given to the Middle and Eastern States of the approach of disturbances of the atmosphere of much value to the agriculturist, the ship owner, and to all others who transact business affected by changes of weather, as well as of importance to the invalid and the traveler. Indeed, with a proper combination of the lines now in operation, daily intelligence might be obtained in the city of Boston which would be of the highest interest to its inhabitants. Professor Henry mentioned Boston in particular, because this city is so situated that the storms, both of the southern and western class, reach it after they have been felt in New York and in other places which are not as far east and north. It is necessary to remark that the same use of the telegraph is in a measure inapplicable to the inhabitants of western Europe, since they live on the eastern side of an ocean and can not be apprised of the approach of storms from the west. For the same reason the general laws of storms are more conveniently studied by the meteorologists of this country than by those of Great Britain and France.

It should be distinctly understood that the remarks which have been made in this communication relate to the more violent changes of the weather which occur in autumn, winter, and spring. The thunder showers which occur almost daily during the warm weather in summer have somewhat of a local character, and commence at the same time, and frequently at the same hour, for several days in succession, at the same and different places, but wherever they commence they move eastward over the country until they are exhausted.

Professor Henry also spoke of the facts collected in regard to the nature of American storms, and their connection with the two great aerial currents continually flowing over the temperate zone. He considered that the great changes of the weather are principally due to the gradual production of an unstable equilibrium in the two currents, by the accumulation of heat and moisture in the lower.

He spoke in high terms of the importance of the labors of Mr. Espy in developing the theory of the upward motion of air, and the evolution of latent heat in the production of storms.

In reply to a question as to the possibility of crossing the Atlantic in a balloon, the Professor stated that he had little doubt, if the balloon could be made to retain the gas, and to ascend into the upper current, it would be wafted across the ocean in the course of three or four days. If it descended into the lower current, it would be carried to the north of east; and if it continued in the upper current, it would reach Europe south of the same point. The course could be changed, within certain limits, by ascending and descending from one current to the other. The late balloon voyage from St. Louis to Jefferson County, N. Y., was of interest in confirming the theoretical direction of the great lower current of this latitude.

BROUN'S LAW OF WINDS AND CURRENTS.

In December, 1871, while in the midst of forecast duty and of an intense study of every observational feature of atmospheric circulation, the Editor had the good fortune to receive a visit from the veteran aeronaut, Samuel A. King, from whom he obtained the loan of a volume of newspaper cuttings describing many of his aeronautical voyages. From this volume he prepared for Mr. King the tables presented on December 16, 1871, published on pages 36–38 of the Bulletin of the Philosophical Society of Washington, Vol. I. The object of this compilation was to show the direction of each of the currents of air into which the balloon ascended on the respective voyages. On that occasion the Editor called attention to the fact that it is rare to find an upper current in a direction opposed to the lowest or surface wind, the deviations being usually between 90° and 135°, but as the balloon ascended but little more than 10,000 feet these records only give us an insight into the nature of the lower system of currents that precede extended storms; the ascensions were made by preference only in the settled, pleasant weather attending areas of high pressure and in the warmer season of the year.

Even before this publication the Editor had been studying the direction of upper clouds, as telegraphed daily to Washington, and displayed on the maps used by him in making up the tridaily "probabilities" of the Signal Service, and had perceived the general and almost invariable rule that the upper cloud directions lie to the right of the lower clouds, and the latter to the right of the winds. In a letter of February, 1872, he said:

> The upper clouds move toward a point on the right-hand side of that toward which the surface winds blow; the angle between these two directions varies from 0 to 180° but is, in a majority of cases, 90°.

This generalization leads to a very simple theory of the upper currents within areas of low pressure, the so-called cyclonic inflow of the winds below and anticyclonic outflow of the cirrus clouds above.

A few months later the Editor stated: "This is evidently only another way of saying that the upper clouds move away from areas of low pressure," and illustrated this by the following five tables for the motions of cirrus and cumulus clouds prepared for Washington, during the months of January to June, 1872.

Tables I and II show, respectively, the number of times that clouds were observed from a given direction when a given surface wind prevailed. The compilation of such tables is a mere matter of counting. Thus, with a northwest wind, cirrus clouds were observed moving from northwest 16 times out of the whole 118 cases.

Table III shows how much any cloud direction deviates to the right (plus) or to the left (minus) from any wind direction. Applying this general table to the data in Tables I and